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CITY OF YORK.

REPORT

TO THE

SEWERAGE COMMITTEE

ON

SEWAGE PURIFICATION EXPERIMENTS

AT THE

NABURN DISPOSAL WORKS

A. CREER,
City Engineer and Surveyor.

GUILDHALL, YORK,
October, 1901.

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Printed by the "Yorkshire Gazette" Limited, 15, High Ousegate.
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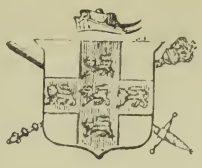
CITY OF  YORK.

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October, 1901.

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SEWAGE PURIFICATION.

TO THE CHAIRMAN AND MEMBERS OF THE SEWERAGE COMMITTEE OF THE CORPORATION.

GENTLEMEN,

In consequence of complaints from the West Riding Rivers Board as to the unsatisfactory character of the effluent turned into the River from the Chemical Precipitation Works at Naburn ; and the request of the Local Government Board that the Corporation should proceed with the further purification of the effluent by passing it through land, I was instructed to open out trial holes in various parts of the 18 acres belonging to this Committee with the view of ascertaining the character of the subsoil and its suitability for the purpose of sewage purification. In due course these were opened up and the results reported to the Committee, with an expression of opinion that the land was most unsuitable for the purpose for which it was required, and that if it was used for sewage treatment the result would inevitably lead to a more serious nuisance than that arising from the flow into the river of effluent from Chemically treated Sewage.

After giving the subject full consideration, the Committee decided in October, 1897, to make an application to the Local Government Board for a loan of £2,500 for the purpose of putting down experimental plant to treat sewage on bacterial lines ; this sum formed part of a larger amount sought to be borrowed, made up of expenditure on the Sewage Scheme in excess of borrowing powers and £5,281 for putting down manholes, flushing tanks, and erecting ventilating shafts on the old sewers in the city.

An enquiry was held at the Guildhall on the 11th day of March, 1898, when the application was opposed by the West Riding Rivers Board, by Lord Wenlock, and the Fishery Board. As a result the loan was not sanctioned.

The Committee were of opinion that to proceed with the preparation of land for the further purification of the sewage effluent would be a waste of money, that the result would not be satisfactory, but would in all probability result in the creation of a greater nuisance than that then complained of from the chemically treated sewage.

Accordingly, in October, 1898, I recommended that "with the view of obtaining reliable data as to the effect of various methods of treatment, experimental works should be laid down so as to provide facilities for treating the sewage by :

(a) Land filtration, the land being properly drained, trenched, and prepared ;

(b) Artificial filters ;

(c) A closed septic tank on a small scale."

The estimated cost of these works was £1,000.

After due consideration the Committee approved of this recommendation ; it subsequently received the formal approval of the Council and was carried into effect at once. Since that date further experiments have been suggested and approved and carried into effect. The results have not in all cases been satisfactory, where they have not been considered so the experiment has been abandoned.

The following is a list of the experiments made :—

No. 1. Treatment of Sewage by Covered Septic Tank and Single Contact.

No. 2. Treatment of Sewage by Double Contact Bacteria Beds.

No. 3. Treatment of Sewage through a Ladder Filter.

No. 4. Treatment of Sewage through Open Septic Tank and Continuous Filtration through a "York" Filter.

No. 5. Treatment by Open Septic Tank and Double Contact Beds.

No. 6. Treatment of Filtrate from Experiment No. 1 through prepared land.

No. 7. Treatment of Sewage by Open Septic Tank and Intermittent Filtration through a Gravel Filter.

A plan is attached hereto showing the extent and position of the various Works.

The Sewage of the City gravitates to the Pumping Station at Fulford, where it is pumped up to the Disposal Works at Naburn.

For some years after the opening of the Works it was found to be necessary to remove, by hand, large quantities of sand that accumulated in the reservoirs or pump culverts, immediately under the Engine House ; often to the depth of three feet. Since November, 1899, however, no such removal has been necessary ; everything that gravitates to Fulford, and passes through the coarse screens, is lifted by the pumps and passes to the Disposal Works ; the Sewage when delivered at Naburn was therefore very much worse to deal with during the bacteriological experiments than it was when the sand was to a large extent deposited at Fulford. Under normal conditions the Sewage occupies about 5 hours in flowing from the centre of the City to the Disposal Works.

All samples taken for Analysis are collected at the Disposal Works; the Sewage is thoroughly mixed up on its way to the Works, but to ensure a fair average sample being obtained, portions were taken every half hour during 10 or 12 hours, generally between 8-0 a.m. and 8-0 p.m. These were put into a bucket, well mixed up, put into Winchester quarts and then sent to Mr. Fairley, F.I.C., of Leeds, or to Dr. Smith, your Medical Officer and Analyst. Samples of the effluents from the Continuous Filter were obtained in a similar way, that is, they represented the flow over a lengthened period. All analyses are in grains per gallon. The provisional standard of purification fixed by the West Riding Rivers Board is one grain per gallon Oxygen Absorbed, and one-tenth of a grain per gallon Albumenoid Ammonia. If the results obtained are compared with these standards some idea will be formed of the degree of purification obtained.

For the purpose of these experiments a 15" pipe drain was laid from the sewage channel above the aluminoferric cage, along the east side of the chemical precipitation tanks, to a gauge chamber at the south side of the tanks where sluice valves and gauges were fixed to control and measure the quantity treated. It must be understood that all the sewage used in the experiments, except where otherwise stated, was Crude Sewage ; it had certainly passed through the coarse screen at the Pumping Works and partially through the half-inch screen fixed in the sewage channel near the end of the rising main, but it had not been in contact with any chemicals nor had it been allowed to settle and deposit any part of the contained solids. The position of the various Beds and Tanks will be seen on the accompanying Plan.

EXPERIMENT No. 1.

CLOSED SEPTIC TANK AND FILTERS.

Tank.

This was the first experiment and comprised one Tank and four Filter Beds, the former constructed entirely of concrete, as nearly airtight as practicable, and of 40,000 gallons capacity; the Sewage flows into the tank by three separate inlets placed 3 feet below the surface level, and is withdrawn at the same level.

Filters.

The Filters are each 40 feet long by 20 feet wide and 3 feet deep, the floor is of concrete and the sides and divisions, of sod walls backed up with clay puddle; owing, however, to the ravages of moles the sod walls were at a later stage removed, and the sides lined with brickwork in cement, the Filters being reduced to half their former area. The filtering material is clinker, cinder, and coke obtained from the Gas Works, Fulford Pumping Station (the residue from the burning of domestic refuse) and from Messrs. Leetham's, Hungate Mills.

Filtering material.

I should state here that very little of the material used in these filtering experiments was of a good, hard quality or of a description best suited for the purpose; very much of it was insufficiently burned, with the result that it soon became disintegrated and fell away to dust or fine grit and was washed out of the Filter with the filtrate.

Grading.

The material was prepared by screening; it was graded from $\frac{3}{8}''$ to $1\frac{1}{4}''$ and put in in 3 layers, the larger material being at the bottom.

Working.

The method of working has been as follows:—The gauge was set so as to allow a flow into the tank at the rate of from 13,000 to 40,000 gallons a day, so that the whole contents of the tank would be

gradually displaced in from one to three days by the fresher Sewage flowing in. The Effluent on leaving the Tank flows into No. 1 Filter; as soon as this is full the valve is closed and that of No. 2 opened, and when full, closed, and No. 3 opened, and so on; the period of time the effluent has been allowed to remain in the Filter has for experimental purposes varied considerably.

The Filters were worked in cycles varying from 8 to 12 hours. For an 8-hour cycle Effluent was allowed to run on to a Filter for 2 hours, it was allowed to stand full for 2 hours, then emptied and allowed to remain empty until the expiration of 8 hours from the time it commenced to fill.

For the longest cycle, *i.e.* 12 hours, the time for filling was extended to 3 hours, the remainder of the 12 hours being taken up with standing full, emptying and standing empty. When the working arrangement admitted each filter-bed had a week's rest alternately, *i.e.* once in every 4 weeks. The best results however, were found to obtain, where a Filter-Bed was $1\frac{1}{2}$ hours filling, 2 hours standing full, and $4\frac{1}{2}$ hours emptying and standing empty.

Period of working.

This Tank and Filters were brought into use on the 21st April, 1899, and with the exception of slight intervals, has been in use ever since. Up to the 31st August, 1901 (*i.e.* over 2 years and 4 months), it has passed over $14\frac{1}{2}$ million gallons; the maximum depth of deposit is about 14 inches. If this quantity of Sewage had been treated by Chemical Precipitation and the resultant sludge passed through the presses, it would have entailed in Chemicals and Pressing a cost of £26 9s. 3d.

Temporary use with Chemically treated effluent.

In the earlier stages, one of these Filters was used for a few weeks for the Effluent from the Chemical Precipitation Tanks so as to ascertain the advantage of passing Chemically treated Sewage through a Bacteria

Filter. This had already been purified to the extent of about 56 per cent. before passing into the Filter. The total purification obtained was from 85 to 90 per cent.

As the object of the experimental plant was to ascertain the advantage of Bacterial methods over that of Chemical treatment, the experiment of filtering Chemically treated Sewage was discontinued and the Filter used along with the other three, for the treatment of effluent from the Closed Septic Tank.

Samples.

The samples were taken from each Filter, half-an-hour after the discharge valve was opened; these were mixed together and the sample for analysis taken.

The results obtained are given in Table No. 1.—Pages 10 and 11.

Purification by percentage.

The method of representing the degree of purification by a percentage is only of value for comparing the results obtained by treating the same Sewage in different ways. As a means of comparing the results obtained in different towns it is useless and very often misleading. A low percentage of purification, in a weak Sewage may, and often does, represent a purer Effluent, than a higher percentage of purification in a strong Sewage.

Analyses.

These Analyses do not show as favourable results as was expected, nor as good as other experiments hereafter referred to. The Albumenoid Ammonia in the effluent has varied from ·03 to ·26, the average being ·159, while the Oxygen Absorbed has varied from ·47 to 2·01, giving an average over the whole analyses of ·94; this is just under the West Riding Rivers Board provisional standard in respect to Oxygen Absorbed, while in respect of Albumenoid Ammonia the average is 50 per cent. over the standard. On only two occasions were slight traces of Calcium Nitrate observable.

TABLE 1.—CLOSED SEPTIC TANK

Date.		Total Solids.		Organic and Volatile Matter.		Free Ammonia.	
		Sew.	Eff.	Sew.	Eff.	Sew.	Eff.
1899.							
August 1st	1st Period of Working April 24th, 1899, to Oct. 28th, 1900.	70.98	53.69	16·24	8·75	2·23	1·16
October 19th.		60·20	47·26	14·87	3·02	4·125	1·56
November 22nd		61·00	51·60	11·23	7·00	3·57	2·52
1900.							
September 6th		58·57	46·67	9·91	4·62	3·50	2·54
September 14th		55·41	52·05	9·35	5·71	4·02	3·31
September 21st		58·99	51·74	10·36	5·29	3·65	2·46
September 29th		57·62	49·84	9·80	5·43	3·42	3·15
Total		422.77	352·85	81·76	39·82	24·515	16·70
Average... ...		60·40	50·40	11·68	5·69	3·502	2·385
1901.							
February 2nd	2nd Period of Working Dec. 10th, 1900, to Aug. 31st, 1901.	Not	ascertained			1·13	1·19
February 11th		do.	do.	do.	do.	2.10	0·14
February 19th		do.	do.	do	do.	1·40	1·155
March 7th		do.	do.	do.	do.	1·54	0·294
March 20th		do.	do.	do.	do.	2·625	1·190
April 11th		do.	do.	do.	do.	2·20	0·98
September 10th.		75·31	54·68	13·02	5·68	5·28	2·24
Total		75·31	54·68	13·02	5·68	16·275	7·189
Average... ...						2·325	1·027

1st Period Purification by Oxygen Absorbed 66·80 per cent.
2nd Period Purification by Oxygen Absorbed 64·15 per cent.

AND FILTERS. **Experiment No. 1.**

Albumenoid Ammonia.		Oxygen absorbed in 4 hours at 80 deg. Fah.		Nitrogen as Calcium Nitrate.		Chlorine.		Sewage.		Effluent.	
								Sediment.	Containing Organic Matter.	Sediment.	Containing Organic Matter.
Sew.	Eff.	Sew.	Eff.	Sew.	Eff.	Sew.	Eff.				
0·43	0·18	3·35	1·10	Under 0·01	Under 0·01	10·68	10·18	Not ascertained			
0·402	0·11	2·125	0·47	Nil	Nil	9·19	7·15	5·60	2·98	1·18	Nil
0·21	0·16	1·62	0·63	Nil	Nil	12·56	9·94	15·02	7·32	Trace	Trace
0·49	0·26	3·01	0·73	Nil	Nil	8·84	7·65	21·29	15·29	Trace	Nil
0·41	0·22	2·03	1·04	Nil	Nil	8·84	8·64	37·48	27·33	Trace	Nil
0·27	0·19	2·91	0·86	Nil	Nil	7·45	7·95	15·28	12·39	Trace	Nil
0·43	0·20	1·97	0·81	Nil	Nil	8·64	7·45	8·46	5·60	Trace	Nil
2·642	1·32	17·015	5·640			66·20	58·96	103·13	70·91		
0·377	0·19	2·430	0·805			9·46	8·42	17·19	11·82		
0·252	0·161	2·09	0·98	Nil	Nil	Not ascertained.					
0·42	0·210	3·07	1·19	Nil	Slight traces	do.	do.	do.	do.	do.	do.
0·945	0·140	3·44	2·01	Nil	Nil	do.	do.	do.	do.	do.	do.
0·28	0·0308	1·223	0·758	Nil	Nil	do.	do.	do.	do.	do.	do.
0·49	0·154	2·43	0·868	Nil	Nil	do.	do.	do.	do.	do.	do.
0·47	0·084	5·57	0·992	Nil	Nil	do.	do.	do.	do.	do.	do.
0·65	0·120	3·23	0.73	Nil	traces	11·64	8·55	11·80	8·12	Trace	Nil
3·507	0·8998	21·053	7·528			11·64	8·55	11·80	8·12		
0·501	0·1285	3·007	1·075								

Purification by Albumenoid Ammonia 49·60 per cent.
Purification by Albumenoid Ammonia 74·35 per cent.

Tank Scum.

The Scum on the surface of this Tank is only about one inch in thickness.

Quantities treated.

As the total quantity passed through the Tank and Filters during the period under review was $14\frac{1}{2}$ million gallons, and taking the area occupied by the Filters at $355\frac{1}{2}$ yards up to Oct. 28th, 1900, and $177\frac{3}{4}$ yards from Dec. 10th, 1900, to August 31st, 1901, it works out for the first period at the rate of 42·89 gallons per square yard per 24 hours, or 207,580 gallons per acre per 24 hours, including rests, and for the second period 121·54 gallons per square yard per 24 hours, or 588,255 gallons per acre per 24 hours.

Remarks.

The results of this experiment were distinctly disappointing; its success in other places leads me to believe either that the system is not so suitable for the purification of York Sewage, as other methods hereafter referred to, or that something in the working and management of the Tank and Filters was wanting to ensure success; this latter is somewhat difficult to realise. Although we had not the automatic arrangement of the Septic Tank Syndicate for actuating the valves of the Filters, they were, so far as I know, opened, and closed at regular intervals. I was over the works very frequently, and have every reason to believe that everything possible was done with the means at our disposal to make the experiment a success.

EXPERIMENT No. 2.

CRUDE SEWAGE AND DOUBLE CONTACT BACTERIA BEDS.

Beds.

There are two Beds, each 90 feet long, by 30 feet wide, by 2 feet 9 inches deep; they have concrete floors and sod walls backed up with clay puddle.

No. 1 Bed is placed at a higher level than No. 2 so that the entire liquid contents of the higher one can be discharged on to the lower.

Filtering material.

The filtering medium in No. 1 Bed is similar in character to that used in the Septic Tank Filters, but larger in size, viz., $1\frac{1}{4}''$ to $3''$, the coarser material being on the top; that in No. 2 is from $\frac{3}{8}''$ to $\frac{3}{4}''$.

Character of sewage treated.

This experiment was a far more severe test than that preceding it. In this case the Raw Sewage was run direct on to No. 1 Bed, and not as in the previous case, subjected to prior treatment or sedimentation in a Tank. The Sewage was taken direct from the sluice chamber—(see plan)—and had only passed through the rough screens through which all the Sewage delivered at the Works has to pass.

Filling filter.

The sluice controlling the flow to the Closed Septic Tank was set so as to discharge at the rate of 28 gallons per minute, and thus pass the full capacity of the Tank once in 24 hours. In the case of the No. 1 Bacteria Bed this was only filled once in 8 hours, or 3 times a day, except on Saturdays, when it was only filled once, and Sundays, when it remained empty the whole day.

Sludging of filter.

Another very serious drawback to the efficient working of these Double Contact Bacteria Beds arose from the large quantity of sludge periodically run on to No. 1 bed. The 15-inch pipe referred to on Page 6 and shown on the plan carried the whole of the Sewage required for these experiments from the Sewage channel to the gauge chamber. From this chamber smaller branches were laid to the various Tanks and Beds.

When No. 1 Bed was filling the sluice was opened to its full extent so as to fill the Bed in the shortest possible time (about 1 hour). The result was that the flow along the 15-inch pipe was for one hour in eight increased from 28 gallons per minute to about 200 gallons per minute ; therefore, for 7 hours in every 8 (and for much longer periods when the beds were resting), this 15-inch pipe was acting as a place of deposit for the solids in the Sewage ; the consequence was that every time the sluice to the No. 1 Bed was opened large quantitiss of sludge were washed out on to the surface.

During the periods of rest allotted to the Bacteria Beds, sometimes 14 days, the accumulation of sludge was sufficient to cover at least one-half of the surface of No. 1 Bed for about 2 inches in depth. In appearance and consistency the sludge was very similar to that deposited in the large tanks by Chemical precipitation. After drying it was found to consist largely of sand, woody fibre, hair, and small pieces of paper.

It will be seen therefore that the Sewage treated on the Bacteria Beds was not only charged with its own proportion of solids but largely also with those from the Sewage passed to the Closed Septic Tank, the Sewage passed to the latter being to a considerable extent clarified or settled Sewage.

Result of resting.

Under these circumstances it is not surprising to find that the liquid capacity of No. 1 Bed was rapidly reduced, though a marked

restoration resulted from periods of rest. See page 17.

Excellent results.

It is for this reason I wish to call the special attention of the Committee to the excellent results obtained under these adverse circumstances. The levels of the ground prevented any other method of supply being adopted, unless a separate pipe drain had been laid from the Sewage channel for each experiment.

The fact of settled Sewage passing into the Closed Septic Tank would not detract, but rather be an aid to its efficient treatment in this Tank.

In this system, as carried out at Exeter and many other places, a Detritus Tank is provided, as a preliminary treatment, so as to intercept sand and other mineral matter from entering the Septic tank.

The table on page 16 shows the results of nine Analyses of Sewage and Effluent :—

Chemical analysis.

The Filtrate by the Albumenoid Ammonia test varied from 0·07 to 0·15 and averaged 0·101, while the Oxygen Absorbed test varied from 0·23 to 0·67 and averaged 0·45.

In both cases the averages were practically within the West Riding Rivers Board Provisional Standard.

On one occasion only was Calcium Nitrate present in the Effluent in measurable quantity, although on five other occasions there were traces.

A comparison with the Standard shows that in the Oxygen Absorbed test the worst results were all better than the Standard, and in the Albumenoid Ammonia test 50 per cent. worse than the Standard.

From these Analyses and the particulars of liquid capacity given later a fairly good idea may be formed of the efficiency of the Double Contact Beds in the economy of Sewage purification.

TABLE 2.—CRUDE SEWAGE AND DOUBLE CONTACT BACTERIA BEDS. **Experiment No. 2.**

Date.	Total Solids.		Organic and Volatile Matter.		Free Ammonia.		Albumenoid Ammonia.		Oxygen absorbed in 4 hours at 80 deg. Fah.		Nitrogen as Calcium Nitrate.		Chlorine.		Sewage.		Effluent.	
															Sediment.	Containing Organic Matter.	Sediment.	Containing Organic Matter.
1899.	Sew.	Eff.	Sew.	Eff.	Sew.	Eff.	Sew.	Eff.	Sew.	Eff.	Sew.	Eff.	Sew.	Eff.				
August 1st	70·98	55·79	16·24	3·78	2·23	1·16	0·43	0·14	3·35	0·67	Under 0·01	Under 0·01	10·68	10·18	Not	ascertained		
October 19th	60·20	44·68	14·87	3·86	4·125	1·23	0·402	0·15	2·125	0·41	Nil	Nil	9·19	6·95	5·60	2·98	0·61	Nil
November 22nd	61·00	66·97	11·23	3·69	3·57	1·01	0·21	0·11	1·62	0·23	Nil	5·33	12·56	12·42	15·02	7·32	Trace	Nil
1900.																		
July 31st	62·33	54·24	10·97	4·76	2·744	0·686	0·378	0·072	2·42	0·641	Nil	traces	10·23	8·94	43·23	Nil	Trace	Nil
September 6th	58·57	50·56	9·91	2·10	3·50	0·80	0·49	0·12	3·01	0·60	Nil	Nil	8·84	8·25	21·29	15·29	Trace	Nil
September 14th	55·41	51·52	9·35	3·16	4·02	0·89	0·41	0·07	2·03	0·27	Nil	traces	8·84	10·13	37·48	27·33	Trace	Nil
September 21st...	58·99	50·26	10·36	3·19	3·65	0·64	0·27	0·11	2·91	0·58	Nil	traces	7·45	8·15	15·28	12·39	Trace	Nil
September 29th	57·62	46·14	9·80	2·83	3·42	0·62	0·43	0·07	1·97	0·24	Nil	Nil	8·64	6·46	8·46	5·60	Trace	Nil
October 13th	41·10	37·10	7·44	4·11	2·41	0·579	0·245	0·072	1·64	0·41	Nil	traces	5·07	5·07	25·47	14·05	Trace	Nil
Total	526·20	457·26	100·17	31·48	29·669	7·615	3·265	0·914	21·075	4·051	Nil	5·33	81·50	76·55	71·83	84·96	0·61	Nil
Average	58·47	50·81	11·13	3·50	3·296	0·846	0·362	0·1015	2·341	0·4501	Nil	0·59	9·06	8·51	21·48	10·62	0·08	Nil

Purification by Oxygen Absorbed... ... ... 80 per cent.
Albumenoid Ammonia ... ... 72 per cent.

The cube contents of each Bed is about 7,425 feet, or 46,000 gallons including the filtering material. Bacteria Beds, Contents.

The Liquid Capacity of No. 1 Bed on the 13th June, 1899, after the clinker had been put in and the bed filled up with Sewage a few times so that the filtering material and sides should be thoroughly saturated, was 18,550 gallons, or about 43 per cent. of the gross contents. Liquid capacity of filter.

Weekly tests were made as to the Liquid Capacity of the Bed, but as no purposes would be served by giving full particulars I will content myself by giving the result of a few observations.

On the 11th September, 1899, after 90 days' use, the Liquid Capacity was reduced to 9,300 gallons, or about 50 per cent. below the liquid capacity on the 13th June, 1899.

The result of a 14 days rest, was, that on September 25th, the Liquid Capacity had increased to 13,650 gallons, or about 27 per cent. below the original Liquid Capacity. By November 6th (42 days) the Liquid Capacity had become reduced to 9,600 gallons, or 48 per cent. below the original figure. In other words, putting the original Liquid Capacity at 100, 90 days work reduced it to 50; a rest of 14 days increased it to 73, and a further 42 days work reduced it to 51.

Subsequent gaugings show the absolute necessity of frequent periods of rest, or a sludging up of the Bed will result.

On several occasions the surface of the Bed had to be forked up, and on two occasions at least, dried sludge, to the extent of a cart load, had to be removed from the surface. Forking up surface.

In no case has the Liquid Capacity of the Bed become reduced to below 9,000 gallons, owing undoubtedly to the Bed being allowed to rest every Saturday afternoon and Sunday. On two occasions it has

been necessary to put additional clinker on to No. 1 Bed owing to the settlement of the material and the falling or disintegration of the clinker, as fine ash was frequently washed out from the bed when the sluice was opened.

No. 2 filter

No appreciable reduction in the Liquid Capacity of Bed No. 2 was observed during the experiment.

Quantity of sewage treated.

During the time these two Beds were in use for the treatment of Crude Sewage, *i.e.*, from June 13th, 1899, to October, 1900—a period of 16 months—9,282,424 gallons of sewage were passed through. This would under ordinary conditions have been treated with aluminoferric, the sludge precipitated and pressed into cake, entailing a cost of about £17. Not only has this been saved, but taking the average results, the effluent from the Double Contact Beds has been 56 per cent. purer by Oxygen absorbed test than that obtained from Chemical Precipitation.

The rate of purification including rests has been $31\frac{1}{2}$ gallons per square yard of Beds, or nearly 153,000 gallons per acre.

Results.

The results obtained in this experiment were on the whole very satisfactory, as will be readily seen from an examination of the Analyses (Table 2) on page 16.

Remarks.

The objections in view of the results obtained by Open Septic Tank and Continuous Filtration are :—

(a) The limited quantity that can be treated per acre of Filter.

(b) The loss of Liquid Capacity in the Beds, and the necessity of renewing the filtering material at intervals, that depend largely on the preliminary sedimentation of the sewage and character of the Filtering Material.

EXPERIMENT No. 3.

LADDER FILTER.

Description.

The third experiment was a Ladder Filter; this was composed of ten chambers, each 4′ 0″ x 3′ 5″ x 2′ 0″ deep, filled with similar clinker to that used in the first experiment; each chamber was placed 6 inches below that next above it, and separated therefrom by a 2″ flag division. A space about 2″ in depth was left under each alternate division. Raw Sewage was run on to the first chamber; it passed through the 2 feet of filtering medium, under the division between Nos. 1 and 2, up through No. 2 chamber, over the division between Nos. 2 and 3, down through No. 3 and so on, passing altogether through about 20 feet of filtering material, the liquid being aerated by coming into contact with the atmosphere in passing over the top of each alternate division; facilities were provided for emptying each pair of chambers for the purpose of aerating. This was brought into use on the 8th June, 1899, with Crude Sewage at the rate of 2760 gallons per day. This continued until the 13th July (35 days). On July 4th the purification was 82 per cent., on the 7th 71 per cent., and on the 13th it had deteriorated so much that the filter was stopped and divided into two separate sections of 5 chambers each. At this date it had been running continuously for 9 days without any aeration except that obtained by the liquid itself running over the chamber divisions.

A start was made on July 17th with Crude Sewage at the rate of 1800 gallons a day to each section.

The table on page 21 gives the result of three analyses of filtrate from this filter :—

On October 19th the Oxygen absorbed was	...	·32
Albumenoid Ammonia	...	·20

The best results were obtained on October 19th, 1899, but, notwithstanding additional periods of rest, the purifying power of the Filter deteriorated steadily, and further experiments with it were abandoned on the 15th September, 1900.

TABLE 3.—LADDER FILTER. **Experiment No. 3.**

Date.	Total Solids.		Organic and Volatile Matter.		Free Ammonia.		Albumenoid Ammonia.		Oxygen absorbed in 4 hours at 80 deg. Fah.		Nitrogen as Calcium Nitrate.		Chlorine.	
1899.	Sew.	Effl.	Sew.	Effl.	Sew.	Effl.	Sew.	Effl.	Sew.	Effl.	Sew.	Effl.	Sew.	Effl.
August 1st	70·98	65·10	16·24	9·38	2·23	2·33	0·43	0·32	3·35	1·76	Under 0·01	Under 0·01	10·68	10·42
October 19th	60·20	38·22	14·87	3·05	4·125	0·96	0·402	0·20	2·125	0·32	Nil.	Nil.	9·19	4·57
November 22nd	61·00	100·32	11·23	8·82	3·57	3·23	0·21	0·15	1·62	1·89	Nil.	Nil.	12·56	20·07
Total	192·18	203·64	42·34	21·25	9·925	6·52	1·042	0·67	7·095	3·97	0·01	0·01	32·43	35·06
Average	64·06	67·88	14.11	7·08	3·308	2·17	0·347	0·22	2·365	1·32	0·003	0·003	10·81	11·68

Purification by Oxygen Absorbed test ... ... 44·2 per cent.
Purification by Albumenoid Ammonia test ... ... 36·6 per cent.

EXPERIMENT No. 4.

OPEN SEPTIC TANK AND CONTINUOUS FILTER.

Preliminary.

The favourable results obtained in the previous experiments, particularly the Double Contact Beds (No. 2) induced the Committee to favourably consider a proposal to further extend the temporary works on Bacteriological lines, and on the 26th February they decided, with the approval of the Council, to convert No. 6 Precipitation Tank into an Open Septic, or Sedimentation Tank, and to construct a Circular Filter for Continuous Filtration. The weak point in the Closed Septic Tank and Filter, and also in the Double Contact Beds, was the comparatively small quantity that could be passed through, per square yard of area per 24 hours, and it was felt that if this quantity could be increased by means of a Filter that would work continuously rather than intermittently, and at the same time produce as good an Effluent, a great advance would be the result.

The estimated cost was £600.

Tank.

This work was put in hand immediately; it necessitated the appropriation of No. 6 Precipitation Tank as an Open Septic Tank and the erection of a special filter for the filtration, or Bacterial Treatment of the Effluent from the Tank.

The alterations to the tank consisted in raising the weir overflow, walling up the Sewage inlet channel, and continuing the 15″ Sewage supply pipe to the N.W. corner of the Tank; from here the pipes (perforated with holes 2″ in diameter) were supported on old iron railway rails laid on brick piers built up 3 feet from the Tank bottom;

They were therefore about midway between the surface and the bottom, and extended the full length of the Tank. For the purpose of drawing off the Effluent similar pipes were laid at the same level along the opposite side of the Tank with branches carried above top water level to discharge into an Open Channel constructed along the south side of the tank. From the end of the channel, 8″ cast iron pipes were laid to the Continuous Filter.

"York" Filter.

The Filter (proposed to be called the "York" Filter) is circular, 67 feet 6 inches in diameter, the floor of Portland cement concrete with radial grooves on the surface $1\frac{1}{2}$″ deep and $1\frac{1}{2}$″ wide, beginning about 3 feet from the centre and terminating at the outer edge, where they are about 6″ apart. From the centre to the circumference the floor has a fall of about 6 inches. Around the floor and forming part of the same construction is a shallow channel 2 feet 6 inches wide to receive the Filtrate as it leaves the Filter.

On the concrete floor, about 6 inches from the channel, a 9″ brick wall is carried up built in pigeon-hole work 8 feet 9 inches in height. The space inside this wall is filled up with clinker and cinder to a depth of $6\frac{1}{2}$ feet. It would have been desirable to use only a clean hard material not likely to fall or become disintegrated by exposure to the Atmosphere, or continuous saturation, but as this class of material could only be obtained at what was considered a prohibitive price, we had to use such material as was easily obtainable from the steam users in the City. Some of the clinker was of fairly good quality, but a large proportion of it was insufficiently burnt, and consequently poor in quality, and even now after thirteen months use continues to come away with the Effluent in the form of very fine ash.

As the clinker was put in and levelled, perforated unglazed pipes 4 inches and 6 inches diameter were laid radially at intervals of 2 feet in height from the floor at three different levels, in all 24 lengths of

these Air Ducts were laid, allowing a free access of air to all parts of the Filter ; to these in a large measure I attribute the successful results obtained. These pipes were invaluable in facilitating the regular observation of Temperatures in the filter during the winter of 1900 and 1901.

8″ cast iron pipes are laid from the end of the Open Channel down to and under the floor of the Filter, then carried up vertically above the surface level of the filtering material.

Distribution.

On the top of the last pipe the distributor is fixed, and as the Tank Effluent enters this, it is spread or distributed equally over the whole area of the Filter in the form of small jets. It trickles down through the filter, emerging at the floor level as a clear and bright liquid, totally devoid of smell and purified to a greater degree than in any of the other experiments.

First filling of tank.

The Tank was filled with Sewage on the 26th June, 1900, and allowed to stand full until July 5th, when it was assumed to be sufficiently prepared for treatment in the Filter. Owing to the difficulty in obtaining clinker there was, at the date it was brought into use, only 5 feet of filtering material in the Filter, and it was not until the 23rd August, 1900, that sufficient material had been obtained to fill up to the full depth of $6\frac{1}{2}$ feet. For the first few weeks effluent from the Open Septic Tank was distributed over the filter at the rate of 210 gallons per square yard per 24 hours, or 1,016,000 gallons per acre per day. On July 24th, 1900, when the filter was passing effluent from the Open Septic Tank, analysis made by Mr. Fairley gave :—Oxygen Absorbed, ·32 ; Albumenoid Ammonia, ·032.

Rests.

The longest rest was from May 16th to May 22nd, 1901 ; this is marked black on the blue line which indicates the quantity passing, the other rests being denoted by spaces. It has been stopped occasionally to improve the distributing arrangements and

when the pumps were stopped. During the whole time from 5th July, 1900, to 31st August, 1901, the Tank and Filter have not been stopped more than 31 days in all.

Quantities treated.

The quantity passed through the Filter during that time has varied from 210 gallons during the first few weeks to 835 gallons per square yard per day. In July, 1901, 715 gallons per square yard per 24 hours, equal to 3,460,000 gallons per acre per day, was continued for 11 days, viz., from July 18th to July 29th. Samples were taken for analysis on both dates with the following results :—

	July 18th, 1901.	July 29th, 1901.	Provisional Standard.
Oxygen Absorbed in four hours.	0·47	0·483	1.00
Albumenoid Ammonia	0·07	0·054	0·100
Nitrogen as Calcium Nitrate ...	5·98	6.89	—

Taking it over the whole period the Tank and Filter have been in use, about 68¾ million gallons have been distributed over the Filter ; and has averaged 174,600 gallons per day since the Filter was completed on August 23rd, 1900. This works out at 440 gallons per square yard per 24 hours, or 2,129,600 gallons per acre.

Cost if treated chemically.

If this Sewage had been treated with Chemicals and the Sludge pressed, the cost to the Committee would have been £125.

Sludge in tank.

On the 9th September, 1901, it was ascertained that the depth of Sludge over the whole area of the tank was equal to 225 cubic yards. This would cost in pressing about £9.

Tank Scum.

A feature of the Open Tank that may be worth recording is that for about 10 months from first bringing the Tank into use as an Open Septic Tank no permanent scum formed on the surface. Occasionally a very light Scum would form over parts of the Tank, but a shower of rain and a moderate breeze was sufficient to disperse it. Prior to the appearance of the Permanent Scum that now covers the tank flakes of sludge would rise to the top, and, having given off the contained gas, would sink again.

The Scum at present covering the Tank averages 2 inches in thickness over the whole surface.

It is evident, therefore, that a Scum on the surface to exclude air and light is not a necessity, but rather an incident in the liquifaction of solids that takes place in the Tank. Some of the best results obtained during the whole time the experiment has been running were obtained before a covering Scum was formed on the Tank.

Pooling on filter surface.

In February of this year a slight pooling was noticed on the surface of the Filter in two places, but it gradually disappeared without any assistance in the way of forking over.

No other pooling has taken place except where the workmen have been standing, *i.e.*, near the wooden bridge and at the centre of the Distributor.

The result of Analyses are shewn in Table No. 4, on Pages 28, 29, 30, and 31.

Diagram shewing chemical analyses, etc.

Sheet No. 1 shows in the form of a diagram,

(*a*) The quantity passing through the Filter in gallons per square yard per 24 hours, by a **Blue Line.**

(*b*) The amount of Oxygen required to Oxidize the organic matters in the **Sewage** at 80 deg. Fah. in four hours, by a **Red Line.**

(*c*) The provisional standard of Purification allowed by the West Riding Rivers Board by a **Black Line.**

(*d*) The amount of Oxygen required to Oxidize the organic matter in the **Filtrate** at 80 deg. Fah. in four hours by a **Red Dotted Line.**

It will be observed that in no case was the degree of impurities in the Filtrate as great as that allowed by the Rivers Board.

Notwithstanding the large increase in impurities in the Sewage on the 11th April, the 15th May, and the 27th June, no corresponding increase is shown in the impurities in the Filtrate, proving that the Filter was able to deal effectively with a very much fouler liquid than the normal flow without any apparent falling off in the quality of the Filtrate.

The diagram shows also very clearly the gradual increase in the quantity per square yard per 24 hours passed through the Filter ; the spaces or intervals in the length of the **Blue Line** indicate the days on which the Filter was not working.

Sheet No. 2 shows in the form of a diagram the same details as **Sheet No. 1,** with the exception that the **Red Line** and the **Red Dotted Line** represent the amount of impurities in the Sewage and Filtrate as represented by the Albumenoid Ammonia.

TABLE 4.—OPEN SEPTIC TANK AND

Date.	Total Solids.		Organic and Volatile Matter.		Free Ammonia.	
1900.	Sew.	Eff.	Sew.	Eff.	Sew.	Eff.
July 24th	55·21	52·92	10·02	7·00	2·94	0·047
July 31st	62·33	53·14	10·97	5·68	2·744	0·021
August 7th	49·70	50·55	19·60	5·84	1·25	0.035
August 17th	58·32	49·50	12·15	4·06	1·86	0·018
August 29th	59·68	53·69	Not as	cert'd	3·82	0·0525
September 6th...	58 57	47·60	9·91	2·74	3·50	0·02
September 14th	55.41	52·50	9·35	4·20	4·02	0·04
September 21st	58·99	50·12	10·36	3·69	3·65	0·12
September 29th	57·62	47·54	9.80	3·58	3·42	0·17
October 13th	41·10	41·44	7·44	3·75	2·41	0·124
October 21st	56·77	55·93	11·27	5·18	3·29	0·21
November 4th...	56·00	52·65	10·85	5·96	3·25	0·168
November 20th	Not ascertained				2·80	0·056
November 29th	do.	do.	do.	do.	1·19	0·112
December 13th	do.	do.	do.	do.	1 12	0·056
December 20th	do.	do.	do.	do.	—	—
December 28th	do.	do.	do.	do.	2·10	0·042
Carried forward ...	669·70	607·58	121·72	51·68	43·756	1·2912

CONTINUOUS FILTER. **Experiment No. 4.**

Albumenoid Ammonia.		Oxygen absorbed in 4 hours at 80 deg. Fah.		Nitrogen as Calcium Nitrate.		Chlorine.		Sewage.		Effluent.	
								Sediment.	Containing Organic Matter.	Sediment.	Containing Organic Matter.
Sew.	Eff.	Sew.	Eff.	Sew.	Eff.	Sew.	Eff.				
0·32	0 032	2·36	0·32	Nil	9·88	7·85	7·95	9·69	7·11	Trace	Trace
0·378	0·039	2·42	0·406	Nil	1·04	10·23	9·14	4·323	20·78	Trace	Trace
0 70	0·0385	2·01	0·415	Nil	7·32	7·84	7·11	Not as	cert'd	Nil	Nil
0·31	0·031	2·60	0·31	Nil	7·80	8·20	7·35	2·72	0 90	Trace	Trace
1·19	0·098	1·875	0·114	Nil	4·90	7·99	6·65	Not as	cert'd	Nil	Nil
0·49	0·05	3 01	0·45	Nil	7 80	8·84	5·96	21·29	15 29	Trace	Nil
0·41	0 05	2·03	0 37	Nil	7 54	8 84	8·84	37·48	27·33	Nil	Nil
0·27	0·05	2·91	0 41	Nil	7·02	7 45	7·45	15·28	12·39	Trace	Nil
0·43	0·09	1 97	0 46	Nil	6·89	8·64	7·15	8·46	5·60	Trace	Nil
0·245	0·07	1·64	0·45	Nil	6·37	5·07	7·23	25·47	14·05	Trace	Nil
0·70	0·054	3·96	0·74	Nil	5 46	4 90	4·14	Not	ascertained		
0·42	0·053	2·89	0·45	Nil	4 95	8 40	8·40	do.	do.	do.	do.
0·36	0 0315	2·72	0 407	Nil	6·30	Not as	cert'd	do.	do.	do.	do.
0·56	0.035	3·04	0·304	Nil	5 76	do.	do.	do.	do.	do.	do.
0·770	0·0308	5·17	0·174	Nil	3·52	do.	do.	do.	do.	do.	do.
—	—	4 30	0·632	Nil	2·52	do.	do.	do.	do.	do	do.
1·05	0·0238	3·90	0·57	Nil	3·15	do.	do.	do.	do.	do.	do.
8·603	0·7766	48·805	6·982	Nil	98·22	94·25	87·37	124·713	103·45	—	—

TABLE 4.—OPEN SEPTIC TANK AND

Date.	Total Solids.		Organic and Volatile Matter.		Free Ammonia.	
	Sew.	Eff.	Sew.	Eff.	Sew.	Eff.
1901. Brought forward...	669·70	607·58	121·72	51·68	43·756	1·2912
January 9th	67·50	50·90	14·78	6·63	2·80	0·07
January 17th	Not	asce	rtai	ned	3·038	0·322
January 24th	do.	do.	do.	do.	1·05	0·154
February 2nd	do.	do.	do.	do.	1·13	0·238
February 11th	do.	do.	do.	do.	2·10	0·273
February 19th	do.	do.	do.	do.	1·40	0·392
February 27th	57·71	47·91	13·27	3·24	2·59	0·448
March 7th	Not	asce	rtai	ned	1·54	0·126
March 20th	do.	do.	do.	do.	2·625	0·182
Ditto	62·32	50·03	13·10	4·08	2·73	0·18
March 29th	Not	asce	rtai	ned	3·50	0·308
April 11th	do.	do.	do.	do.	2·20	0·226
April 25th	do.	do.	do.	do.	3·50	0·504
May 9th...	do.	do.	do.	do.	2·10	0·182
May 15th	do.	do.	do.	do.	2·30	0·252
May 28th	do.	do.	do.	do.	3·62	0·322
June 6th	do.	do.	do.	do.	3·76	0·56
June 20th	79·87	59·72	7·42	6·35	4·66	0·021
June 27th	Not	asce	rtai	ned	4·51	0·024
July 9th	do.	do.	do.	do.	3·90	0·084
July 18th	64·96	55·49	7·50	2·85	2·73	0·18
July 29th	78·23	52·39	10·80	5·91	2·648	0·468
August 19th	Not	asce	rtai	ned	3·60	0·21
Total	1080·29	924·02	188·59	80·74	107·787	7·0175
Average	60·01	51·33	11·09	4·75	2·764	0 1799

Purification by oxygen absorbed ... 84·5 per cent.

CONTINUOUS FILTER.—*Continued.* **Experiment No. 4.**

Albumenoid Ammonia.		Oxygen absorbed in 4 hours at 80 deg. Fah.		Nitrogen as Calcium Nitrate.		Chlorine.		Sewage.		Effluent.	
								Sediment.	Containing Organic Matter.	Sediment.	Containing Organic Matter.
Sew.	Eff.	Sew.	Eff.	Sew.	Eff.	Sew.	Eff.				
8·603	0·7766	48·805	6·982	Nil	98·22	94·25	87·37	124·713	103·45		
0·66	0·035	2·40	0·36	Nil	4·68	6·30	4·73	20·19	17·70	Trace	Nil
0·476	0·0210	2·153	0·673	Nil	4·20	Not	ascertained				
0·35	0·0308	1·615	0·538	Nil	10·08	do.	do.	do.	do.	do.	
0·252	0·049	2·09	0·82	Nil	14·77	do.	do.	do.	do.	do.	
0·42	0·0385	3·07	0·86	Nil	10·25	do.	do.	do.	do.	do.	
0·945	0·0602	3·44	0·896	Nil	4·91	do.	do.	do	do.	do.	
0·49	0·045	2·17	0·500	Nil	3·25	6·49	6·07	16·07	6·41	Trace	Nil
0·28	0·049	1·223	0·303	Nil	4·10	Not	ascertained				
0·49	0·042	2·43	0·395	Nil	6·56	do.	do.	do.	do.	do.	
0·385	0·042	2·06	0·38	Nil	3·77	7·28	6·69	do.	do.	do.	
0·385	0·049	2·59	0·294	Nil	6·15	Not as	certain'd	do.	do.	do.	
0·47	0·055	5·57	0·609	Nil	10·25	do.	do.	do.	do.	do.	
0·67	0·084	3·34	0·445	Nil	16·40	do.	do.	do.	do.	do.	
0·37	0·035	5·55	0·473	Nil	11·07	do.	do.	do.	do.	do.	
0·42	0·0504	6·95	0·550	Nil	20·51	do.	do.	do.	do.	do.	
0·40	0·0476	3·50	0·35	Nil	13·53	do.	do.	do.	do.	do.	
0·51	0·616	4·17	0·517	Nil	8·61	do.	do.	do.	do.	do.	
0·78	0·054	2·24	0·374	Nil	9·75	21·05	9·74	23·31	17·61	Trace	Nil
0·69	0·059	5·07	0·54	Nil	16·40	Not	ascertained				
0·58	0·0574	2·89	0·412	Nil	16·40	do.	do.	do	do.	do.	
0·46	0·07	2·41	0·47	Nil	5·98	10·96	9·93	43·01	26·74	Trace	Nil
0·416	0·054	2·458	0·483	Nil	6·89	15·13	6·81	Not	ascertained		
0·43	0·064	2·79	0·515	Nil	17·22	Not as	certain'd	do.	do.	do.	
19.932	1·9301	120·984	18·739	Nil	323·95	161·46	131·34	227·29	171·91		
0·511	0·0494	3·024	0·468	Nil	8·09	8·97	7·29	18·94	14·33		

Purification by albumenoid ammonia ... 90·0 per cent.

Temperatures.

At the suggestion of Mr. Bicknell, Local Government Board Inspector, numerous observations were taken during last winter of the temperatures of the Sewage, Filter Bed, Filtrate, and Atmosphere. The aerating pipes in the Filter gave facilities for these observations at various heights, and distances from the centre of the bed.

The Average Temperatures from January 9th to February 19th, 1901, taken at positions at a distance of three feet into the Filter was 41 deg. Fah. At 13 feet into the filter 42·9 deg. Fah. At 29½ feet into the Filter 43·7 deg. Fah.

The Average of the Sewage during the same period taken daily at 9 a.m. and 9 p.m. was 42·9 deg., the Atmosphere 34·8, and the Filtrate 39·9.

On Jan 9th, when the Atmosphere was 23 deg., the Average Temperature of the Filter at 3 feet in, was ... 42·2

13	do.	do.	...	42·7
29½	do.	do.	...	43·9

The Sewage at the same time was 45 deg., the Open Septic Effluent 41 deg., and the Filtrate 42 deg.

For further particulars see Diagram **Sheet No. 3.**

State of filtering material.

That portion of Filtering Material near the surface is covered with a gelatinous substance containing a large number of small threadlike worms ; some are red in colour, while others have the same colourless appearance as the substance adhering to the cinder ; in addition to the worms there are large numbers of small flies, and these are found not only in the pigeon-holes of the containing wall and immediately under the surface, but throughout the whole of the filter where it has been examined. Occasionally large numbers of the worms are washed out, and this probably accounts for the presence of so many fish at the outlet from this experiment.

EXPERIMENT No. 5.

OPEN SEPTIC TANKS AND DOUBLE CONTACT BEDS.

The same beds that were in use for Experiment No. 2 were, after 39 days rest, used for this Experiment also. During the rest the Bed had been forked up, about 6″ of the top filtering material removed and replaced with clean cinder and clinker of the same size. No. 1 bed.

On November 23rd, 1900, work was commenced, with three fillings per day of Effluent from the Open Septic Tank and continued until July 1st, 1901. During this period 4,890,000 gallons of Open Septic Effluent was passed through these Filters, equal to 37 gallons per square yard of Filter per 24 hours. Quantities.

Notwithstanding the 39 days rest and the renewing of part of the material, the No. 1 Bed did not recover its Liquid Capacity. This can only be accounted for by assuming that a large quantity of sand and other matter had been washed into the Filter during the time it was being treated with Crude Sewage. On opening down the material was found to have solidified to a considerable extent and to be like ordinary soil, with a mixture of ashes and fibrous material. Between January 21st and July 1st the Filter lost in Capacity about 24 per cent. The Filtrate, however, on the Average gave better results by the Albumenoid test, but not quite so good by the Oxygen Absorbed Test as the Filtrate from the same Beds when treated with Raw Sewage.

The following table gives the results of 16 analyses.

TABLE 5.—BACTERIA BED WITH OPEN

Date.	Total Solids.		Organic and Volatile Matter.		Free Ammonia.	
1900.	Sew.	Eff.	Sew.	Eff.	Sew.	Eff.
November 29th	Not	asc	ertai	ned	1·19	0·28
December 13th	do.	do.	do.	do.	1·512	0·28
December 20th	do.	do.	do.	do.	Not	asc
December 28th	do.	do.	do.	do.	2·10	0·046
1901.						
January 9th	67·50	44·46	14·78	2·10	2·80	0·62
January 17th	Not	asc	ertai	ned	3·038	0·448
January 24th	do.	do.	do.	do.	1·05	0·182
February 2nd	do.	do.	do.	do.	1·13	0·350
February 11th	do.	do.	do.	do.	2·10	0·49
February 19th	do.	do.	do.	do.	1·40	0·546
February 27th	57·71	47·74	13·27	3·50	2·59	0·518
March 7th	Not	asc	ertai	ned	1·54	0·154
March 20th	do.	do.	do.	do.	2·625	0·504
March 29th	do.	do.	do.	do.	3·50	0·52
April 11th	do.	do.	do.	do.	2·20	0·41
April 25th	do.	do.	do.	do.	3·50	0·672
Total	125·21	92·20	28·05	5·60	32·275	6·020
Average	62·60	46·10	14·025	2·80	2·151	0·401

Purification by Oxygen Absorbed 78·6 per cent.

SEPTIC TANK EFFLUENT. **Experiment No. 5.**

Albumenoid Ammonia.		Oxygen absorbed in 4 hours at 80 deg. Fah.		Nitrogen as Calcium Nitrate.		Chlorine.		Sewage.		Effluent.	
								Sediment.	Containing Organic Matter.	Sediment.	Containing Organic Matter.
Sew.	Eff.	Sew.	Eff.	Sew.	Eff.	Sew	Eff.				
0·56	0·196	3·04	0·652	Nil	2·10	Not ascertained.					
0·770	0·0336	5·17	0·487	Nil	Trace	do.	do.	do.	do.	do.	do.
ertained		4·30	1·05	Nil	traces	do.	do.	do	do.	do.	do.
1·05	0·0504	3·90	0·59	Nil	2·94	do.	do.	do.	do.	do.	do.
0·66	0·067	2·40	0·36	Nil	0·52	6·30	4·73	20·19	17·70	Trace	Nil
0·476	0·0233	2·153	0·498	Nil	2·31	Not ascertained.					
0·35	0·042	1·615	0·403	Nil	6·15	do.	do.	do.	do.	do.	do.
0·252	0·056	2·09	0·67	Nil	5·74	do.	do.	do.	do.	do.	do.
0·42	0·077	3·07	0·79	Nil	7·38	do.	do.	do	do.	do.	do.
0·945	0·0770	3·44	0·827	Nil	2·71	do.	do.	do.	do.	do.	do.
0·49	0·045	2·17	0·419	Nil	traces	6·49	6·04	16·07	6·41	Trace	Nil
0·28	0·0518	1·223	0·293	Nil	1·64	Not ascertained.					
0·49	0·070	2·43	0·973	Nil	traces	do.	do.	do.	do.	do.	do.
0·385	0·089	2·59	1·18	Nil	traces	do.	do.	do.	do.	do.	do.
0·47	0·053	5·57	0·557	Nil	traces	do.	do.	do.	do.	do.	do.
0·67	0·0882	3·34	0·604	Nil	Nil	do.	do.	do.	do.	do.	do.
8·268	1·0193	48·501	10·353	Nil	31·49	12·79	10·77	36·26	24·11		
0·551	0·0679	3·031	0·647	Nil	1·97	6·39	5·38	18·13	12·05		

Purification by Albumenoid Ammonia 87·6 per cent.

A comparison of Tables 2 and 5 will shew the difference in results obtained by treating Crude Sewage and Open Septic Effluent in the same Filter. In the case of Crude Sewage the final result shewed that the percentage of purification was 80 per cent. and 72 per cent. respectively for Oxygen Absorbed and Albumenoid Ammonia. In the case of Open Septic Effluent the final results give the percentage of purification as 78·6 and 87·6 respectively for Oxygen Absorbed and Albumenoid Ammonia. Further than this, in the former case on no occasion was the result either in Oxygen Absorbed or Albumenoid Ammonia above the Standard of Purification allowed by the Rivers Board, while in the latter case the results were above the Standard on three occasions. It would therefore appear that a better result can be obtained by the treatment of York Crude Sewage on Bacteria Beds than by means of the same beds after Sedimentation or preliminary treatment in an Open Septic Tank.

Sheet No. 4 shows :—

(*a*) The Quantity passing the Filter in gallons per square yard per 24 hours by a **Blue Line.**

(*b*) The amount of Oxygen required to Oxidize the Organic matters in the **Sewage** at 80 deg. Fah. in four hours by a **Red Line.**

(*c*) The provisional Standard of Purification allowed by the West Riding Rivers Board by a **Black Line**.

(*d*) The amount of Oxygen required to Oxidize the organic matter in the **Filtrate** at 80 deg. Fah. in four hours by a **Red Dotted Line.**

Sheet No. 5 shows in the form of a diagram the same details as **Sheet No. 4** with the exception that the Red Line and the Red Dotted Line represent the amount of impurities in the Sewage and Filtrate as represented by the Albumenoid Ammonia.

EXPERIMENT No. 6.

SEPTIC FILTER EFFLUENT THROUGH LAND.

Prepared plots.

One quarter acre of land was trenched $2\frac{1}{2}$ feet deep by spade labour, underdrained, levelled and divided into two plots each $\frac{1}{8}$ acre.

Effluent from closed septic filters.

On June 14th, 1899, Effluent from the Closed Septic Tank Filters was run on to this land, the surface being formed in shallow furrows and ridges ; each plot was treated with the Effluent from a Filter Bed alternately.

Results.

During July and August 8 tests were made to ascertain the Purification effected ; this was found to average 89 per cent., while Filtrate from No. 2 Bacteria Bed taken under similar circumstances and at the same time averaged 83 per cent.

Chemical analyses of the Septic Filter Effluent as it left the Filter, and of the flow from Land were made on the 1st August, and showed :—

	From Filter.	From Land.
Oxygen Absorbed in 4 hours ...	1·1	0·79
Albumenoid Ammonia	0·18	0·15

The Double Contact Bacteria Beds analysed at the same time gave :—

Oxygen Absorbed	0·67
Albumenoid Ammonia	0·14

Surface caking over.

Soon after this date the surface of the land began to cake over, and the Septic Filter Effluent would lie on the surface for weeks. Long periods of rest did not improve the land for Filtering purposes ; its regular use was discontinued, and only an occasional discharge from a Filter-bed put on to it.

Inspection.

On the 4th November one of the Engineering Inspectors of the Local Government Board made an inspection of the works, and asked particularly to be shown the Prepared Plots of land.

The day before his visit Closed Septic Filtrate had again been turned on to the land, after a 15 days rest, though the surface was not then clear of the Filtrate put on 15 days before.

As showing the unsuitability of the Land for Filtration purposes a hole 18″ long by 9″ wide and 12″ deep was made in one of the shallow furrows in plot **No. 2.** The Filtrate running along the furrow immediately filled the hole. A second hole of similar size was made on the ridge immediately adjoining at a distance of 9 inches from the first hole. This was perfectly dry, the intervening space was gradually sliced away until only two inches separated the two holes, there was still no sign of moisture in hole No. 2.

A pencil was then forced into the slight barrier of soil separating the holes for $\frac{3}{4}$″, still no moisture, and it was only when the point of the pencil was passed through to hole No. 1 that a slight trickle came through into No. 2 hole. By this time the side of No. 2 showed signs of sweating.

This showed, I think, conclusively that if this Land had been laid out and prepared either as a Sewage Farm or as an adjunct to Purification after Preliminary Treatment by other means, failure would have been the inevitable result.

EXPERIMENT No. 7.

OPEN SEPTIC TANK AND INTERMITTENT FILTER.

This consisted of an Open Chamber 7′ 10″ by 7′ 10″ by 1′ 9″ deep to hold about 656 gallons, provided with one of Adams' Automatic Syphons. The Filter was 19′ 4″ by 11′ 3″ by 3′ 0″ deep, built of pigeon-hole brickwork and filled with clean gravel graded to three sizes, viz., nine inches of $1\frac{1}{2}$″ at the bottom, then nine inches of $\frac{3}{4}$″, then nine inches of $\frac{1}{2}$″, four and a half inches of $\frac{3}{8}$″, and four and a half inches of coarse sand. Tank.

The Syphon Discharging Chamber was filled by a branch pipe from the supply to the Continuous Filter, controlled by a sluice ; this could be set so as to fill the chamber in any given time. On reaching the required depth the syphon discharged the contents by means of a perforated trough over the whole surface of the Filter, covering it to a depth of about 2 inches ; the liquid percolated through the Filter, flowing out at the bottom into a receiving well. Notwithstanding that various periods of discharge were tried no satisfactory Filtrate resulted over the eight months the experiment was in operation. Filter.

A Summary of Results and Quantity Treated per square yard per 24 hours is given on Table No. 6, page 40.

TABLE No. 6.

SUMMARY OF AVERAGE ANALYSES AND WORKING CAPACITY OF FIVE EXPERIMENTS.

	No. 1 Experiment. Closed Septic Tank & Filters.				No. 2 Experiment (Double Contact Bacteria Beds).		No. 3 Experiment (Ladder Filter).		No. 4 Experiment (Open Septic Tank and Continuous Filter).		No. 5 Experiment (Double Contact Bacteria Beds with Open Septic Tank Effluent).	
	1st period April 24th, 1899, to Oct. 28th, 1900.		2nd period Dec. 10th, 1900, to Aug. 31st, 1901.									
	Sew.	Effl.	Sew.	Effl.	Sew.	Effl.	Sew.	Effl.	Sew.	Effl.	Sew.	Effl.
Oxygen absorbed	2.430	0·805	3·007	1·075	2·341	0·4501	2·365	1·32	3·024	0·468	3·031	0·647
Albumenoid Ammonia.	0·377	0·190	0·501	0·1285	0·362	0·1015	0·347	0·22	0·511	0·0494	0·551	0·0679
Nitrogen as Calcium Nitrate.....	Nil	Nil	Nil	Nil	Nil	0·59	Nil	Nil	Nil	8·09	Nil	1·97
Gallons passing per square yard per 24 hours	42·89		121·54		31·57		72·47		440·00		37·04	
Gallons per acre per 24 hours	207,580		588,255		152,815		350,737		2,129,600		179,298	

The experiment that recommends itself to me as most worthy of the future consideration of the Committee is No. 4, viz. : Open Septic Tank and Continuous Filtration. My reasons are :— General remarks.

1. The Excellent Results obtained as shown by Chemical Analyses.

   (*a*) The Average Purification by the Oxygen Absorbed test is 84·4 per cent, and is 53 per cent. purer than the Provisional Standard of Purification fixed by the West Riding Rivers Board.

   (*b*) The Average Purification by Albumenoid Ammonia test is 90 per cent., and is 49 per cent. purer than the Standard of Purification fixed by the West Riding Rivers Board.

2. The Filtrate is Non-Putrescible.

3. The System is adaptable for Larger Quantities per Square Yard than any other experiment, and is thus as well able to deal with Storm Water as with Crude Sewage.

4. There is no loss of Liquid Capacity in the Filter, though in all probability the Filtering Material may require renewing; this, however, will depend to a considerable degree on the quality and suitability of the material used.

I estimate that the cost of providing increased Tank capacity and providing Filters to deal with the whole of the Sewage pumped to Naburn will be £25,000, including about £2,000 for piling the river bank alongside the Filters. If the Effluent is carried below the Naburn Weir an additional outlay of about £10,000 will be required.

It will probably be necessary at some future time to make special provision for the treatment of storm water before passing it into the river at Fulford ; in my opinion this could be done more economically

at Fulford than at Naburn by providing large roughing Filters or Tanks filled with clinker, the storm water being pumped direct into the tanks and allowed to flow through the Filters direct into the River ; these would only be brought into use when the storm water exceeded in quantity the pumping power at Fulford or in a case of a Breakdown of the Machinery.

I am, Gentlemen,

Your obedient Servant,

A. CREER,

City Engineer and Surveyor.

GUILDHALL,

12th October, 1901.

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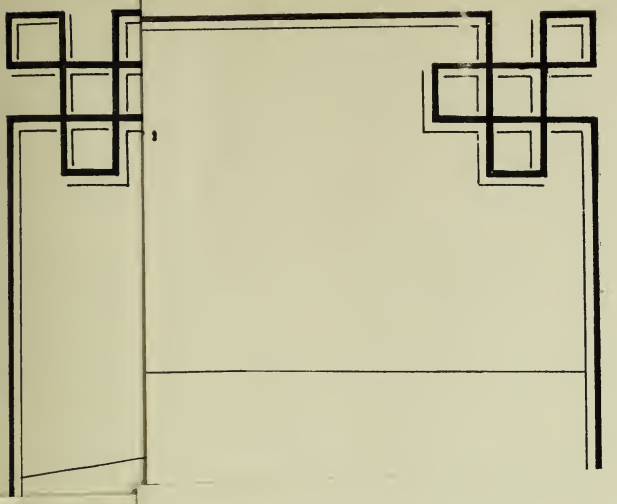
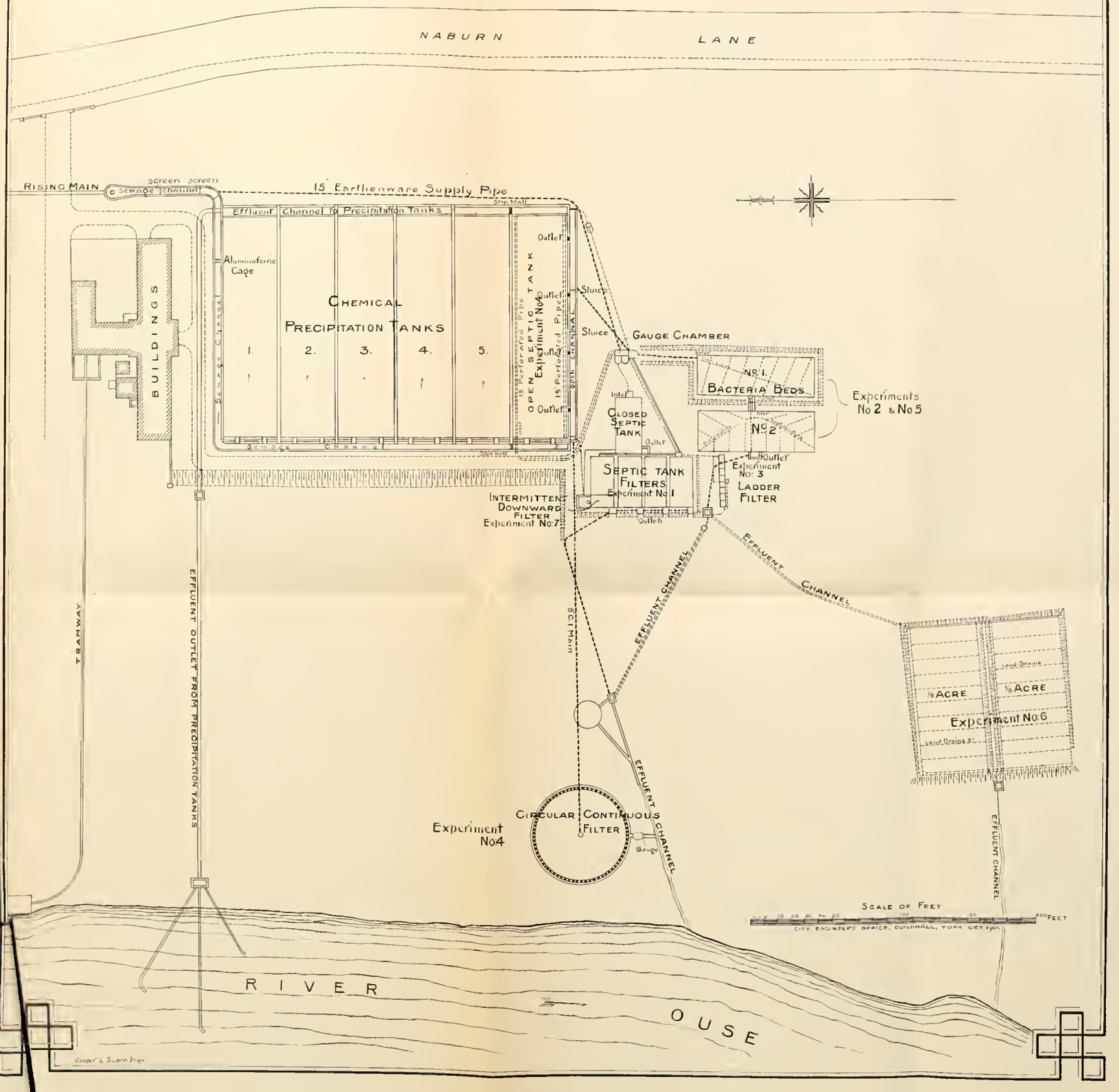
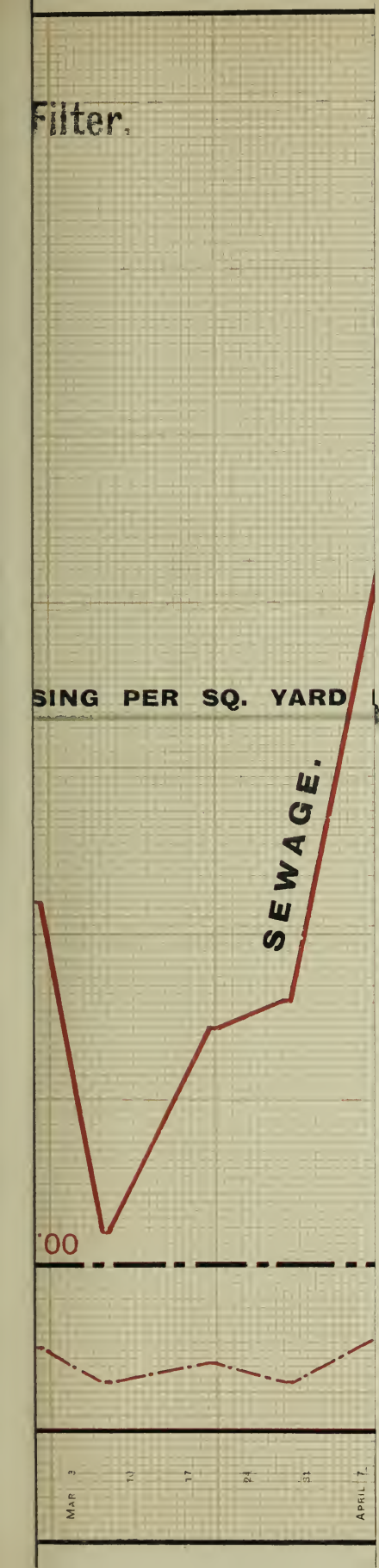


CITY OF YORK SEWAGE DISPOSAL.

PLAN OF EXPERIMENTAL WORKS, NABURN.




Filter.
SING PER SQ. YARD
SEWAGE.
'00
MAR 3
10
17
24
31
APRIL 7

EXPERIMENT No. 4.

SHEET No. 1.

Open Septic Tank and Continuous Filter.

OXYGEN ABSORBED.

OXYGEN ABSORBED IN 4 HOURS AT A TEMPERATURE OF 80 FAH RED LINE

QUANTITY PASSING PER SQ. YARD PER 24 HOURS.

SEWAGE.

SEWAGE.

WEST RIDING RIVERS BOARD PROVISIONAL STANDARD OF PURIFICATION 1·00

EFFLUENT

EFFLUENT

JULY 1900 Week Ends JULY 28 AUG. SEP. OCT. NOV. DEC. JAN. 1901 FEB. MAR. APRIL MAY JUNE JULY

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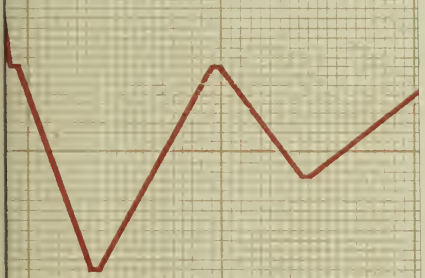
A.

SSING PER SQ. YARD



O.

EFFLUEN

MAR. 3 10 17 24 31 APRIL 7

EXPERIMENT No. 4.

SHEET No. 2

Open Septic Tank and Continuous Filter.

ALBUMENOID AMMONIA.

ALBUMENOID AMMONIA (RED LINE).

QUANTITY PASSING PER SQ. YARD PER 24 HOURS.

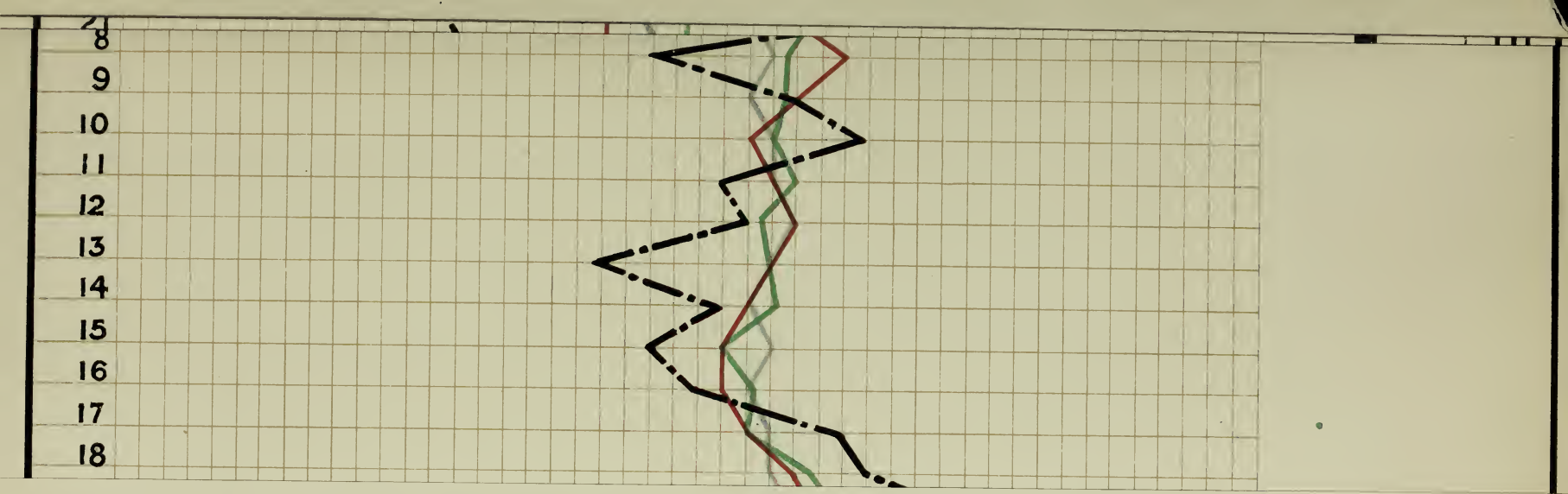
SEWAGE.

SEWAGE.

WEST RIDING RIVERS BOARD PROVISIONAL STANDARD OF PURIFICATION 0·10.

EFFLUENT

EFFLUENT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OPEN SEPTIC TANK and CONTINUOUS FILTER.

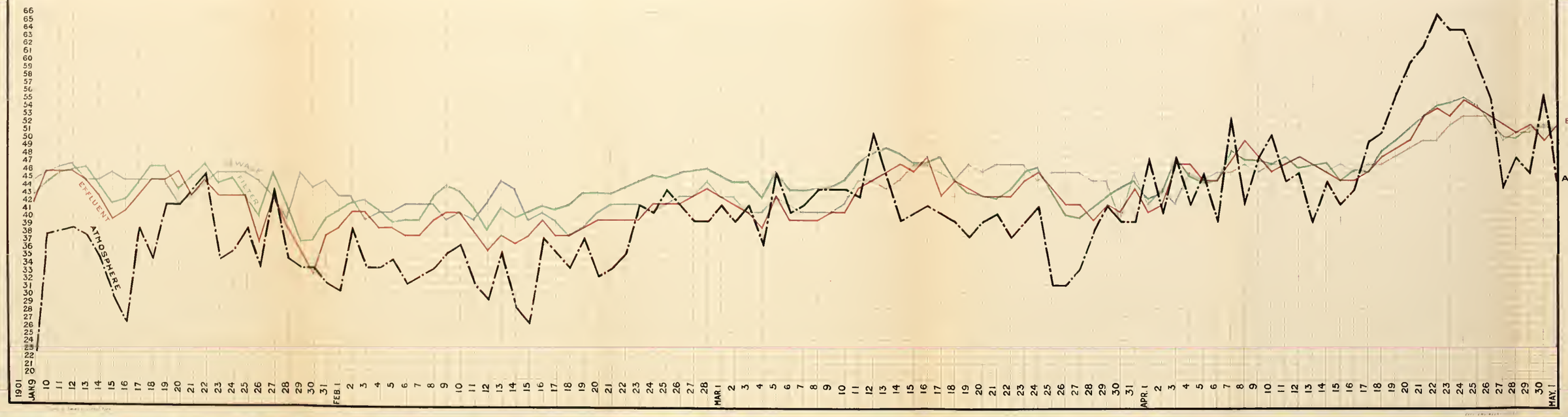
SHEET No 3

RECORD OF TEMPERATURES OF

Atmosphere, Sewage, Filter and Filter Effluent,

JANUARY 9 and MAY 1, 1901.

EXPERIMENT No. 4.



SHEET No. 4

OXYGEN ABSORBED IN 4 HOURS AT A TEMPERATURE OF 80° FAH. (RED LINE.)

WEST RIDING

Week End 25

DEC. 2 9 16 23

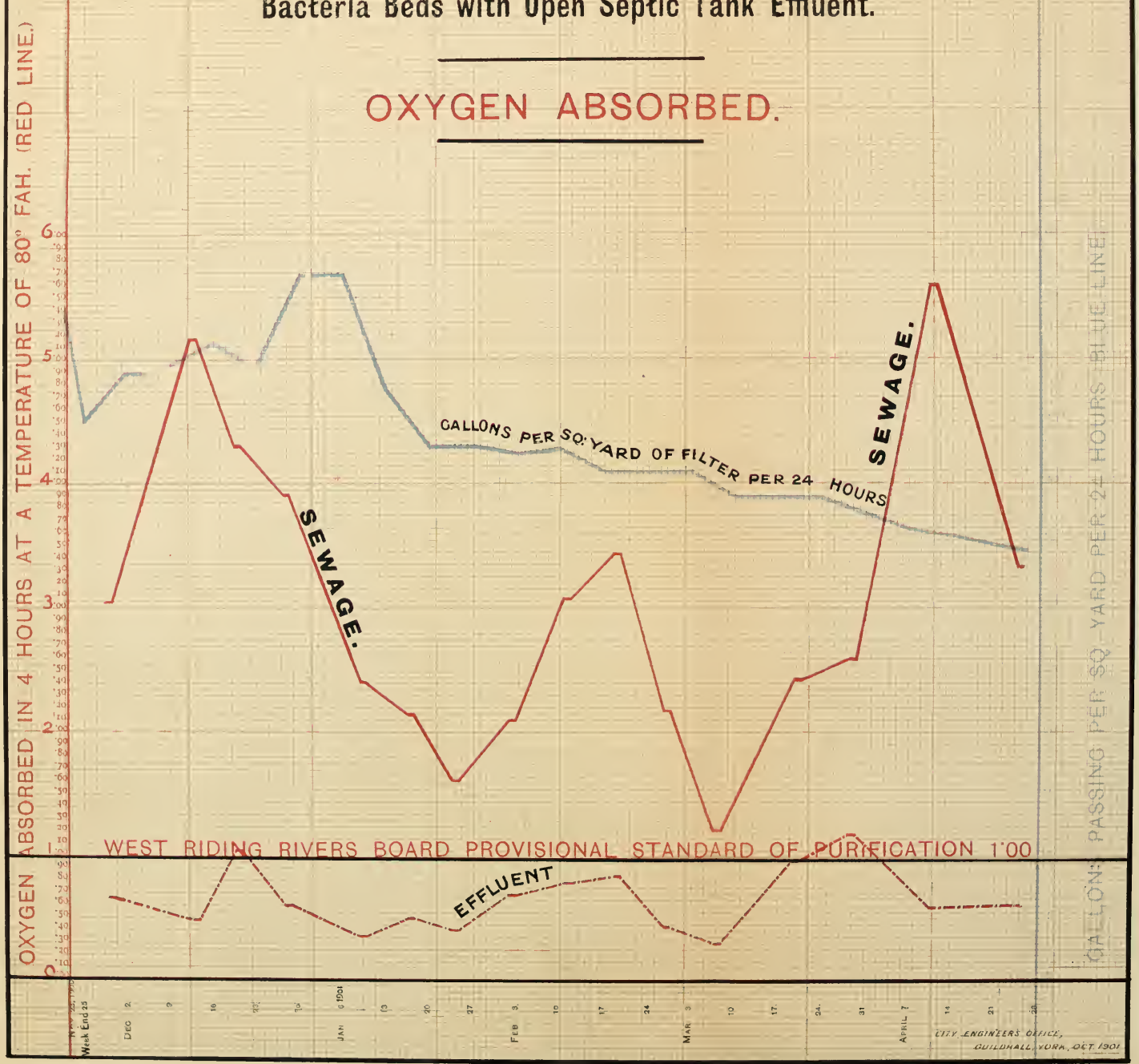
Cooper & Swann Lithos, York

SHEET No 4

EXPERIMENT No. 5.

Bacteria Beds with Open Septic Tank Effluent.

OXYGEN ABSORBED.



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GUILDHALL, YORK, OCT. 1901

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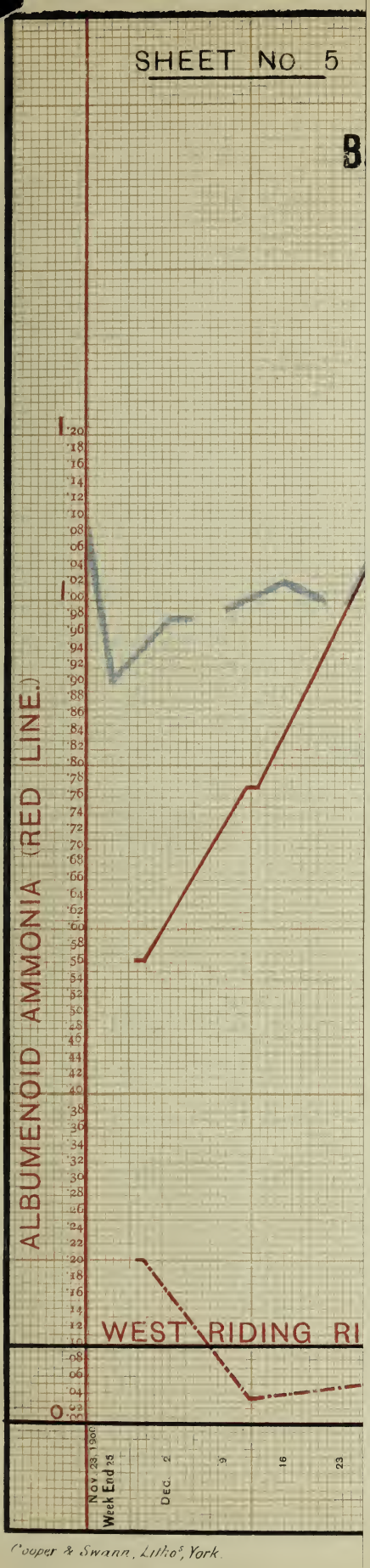

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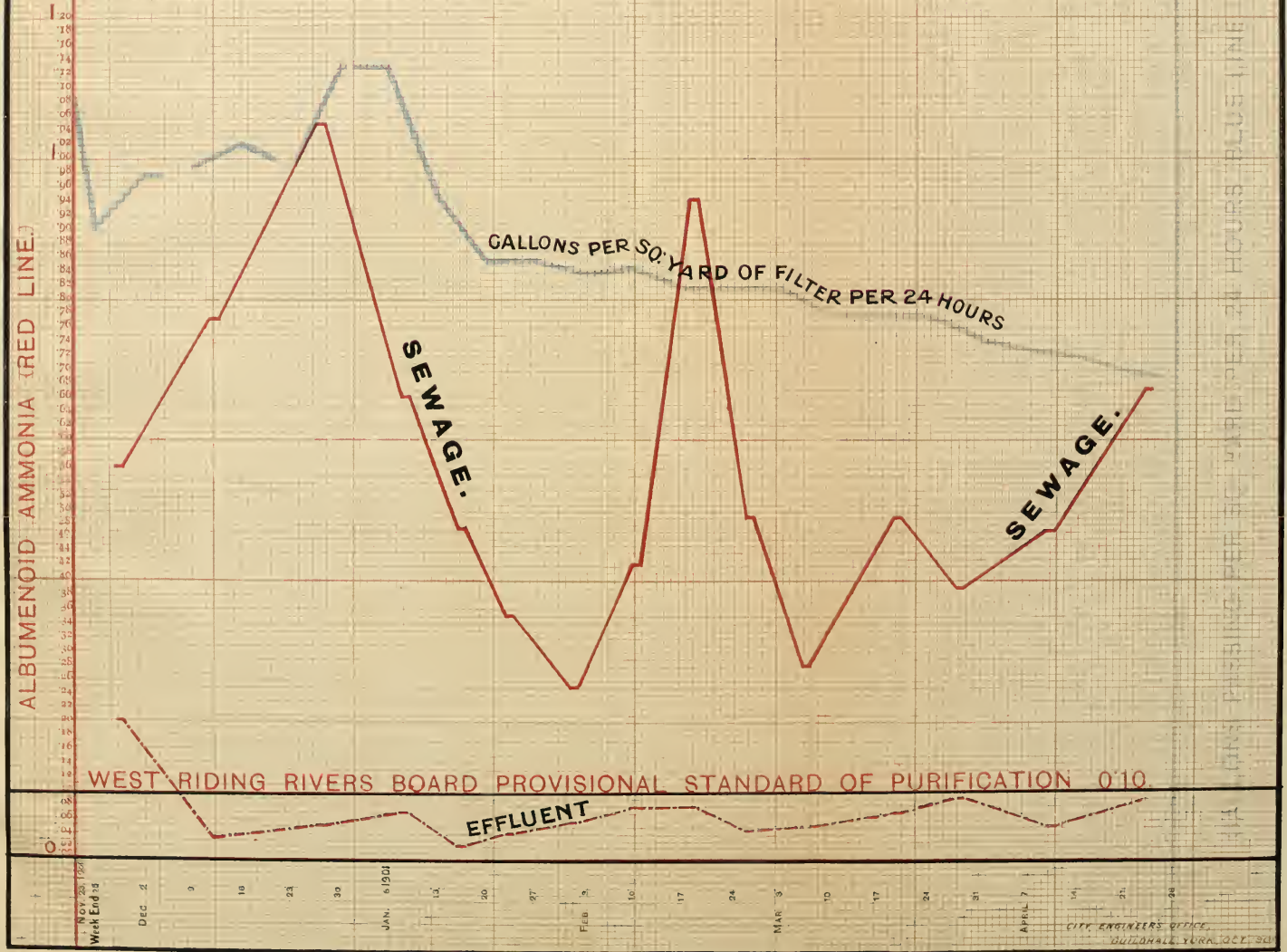
SHEET NO 5

EXPERIMENT NO. 5

Bacteria Beds with Open Septic Tank Effluent.

ALBUMENOID AMMONIA.



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